

TAPIR

Theoretical Astrophysics Including Relativity & Cosmology

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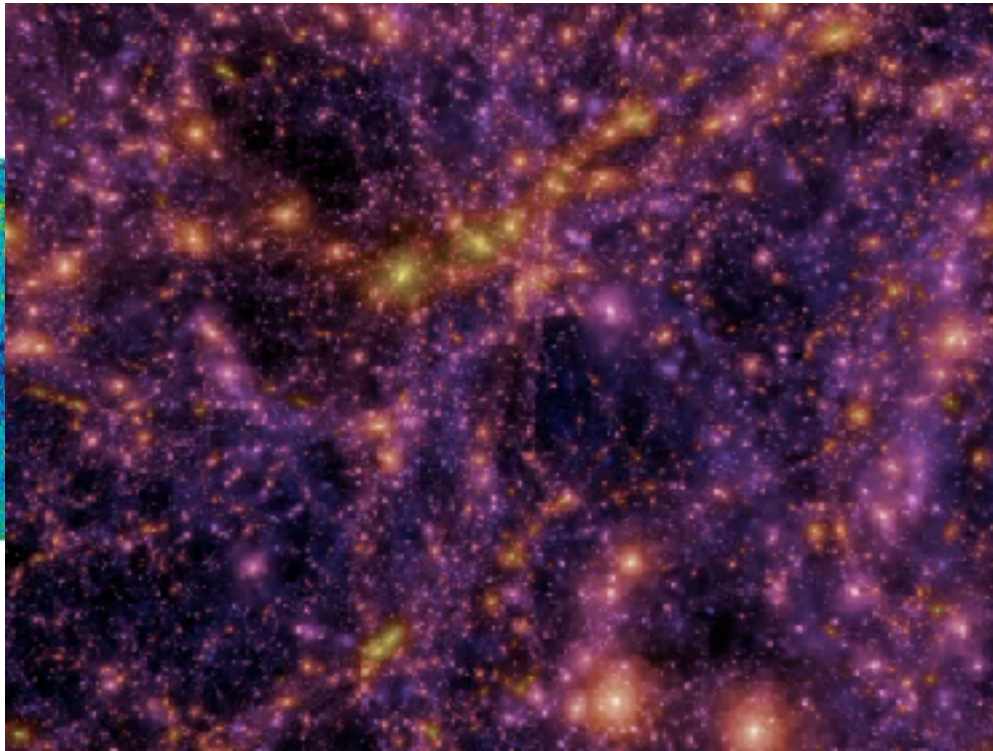
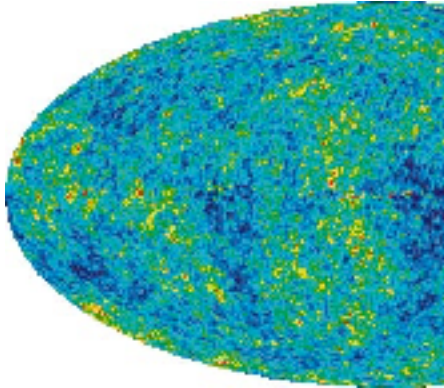


Cahill Center for Astronomy and Astrophysics, **3rd Floor**

Cosmology & Galaxy Formation

- HOW DO WE GO FROM BIG BANG TO MILKY WAY?

$z \sim 1090$
($t \sim 400,000$ yr)



Today



- Formation of structure in the Universe
- Probes of dark matter & dark energy
- Galaxy formation: why do our models fail so badly?



**Philip
Fajardo-Hopkins**

Sean Carroll



Olivier Dore

From Galaxies to Planets

- SCALES $\sim 10^{12}$ - 10^{28} cm

Jim Fuller



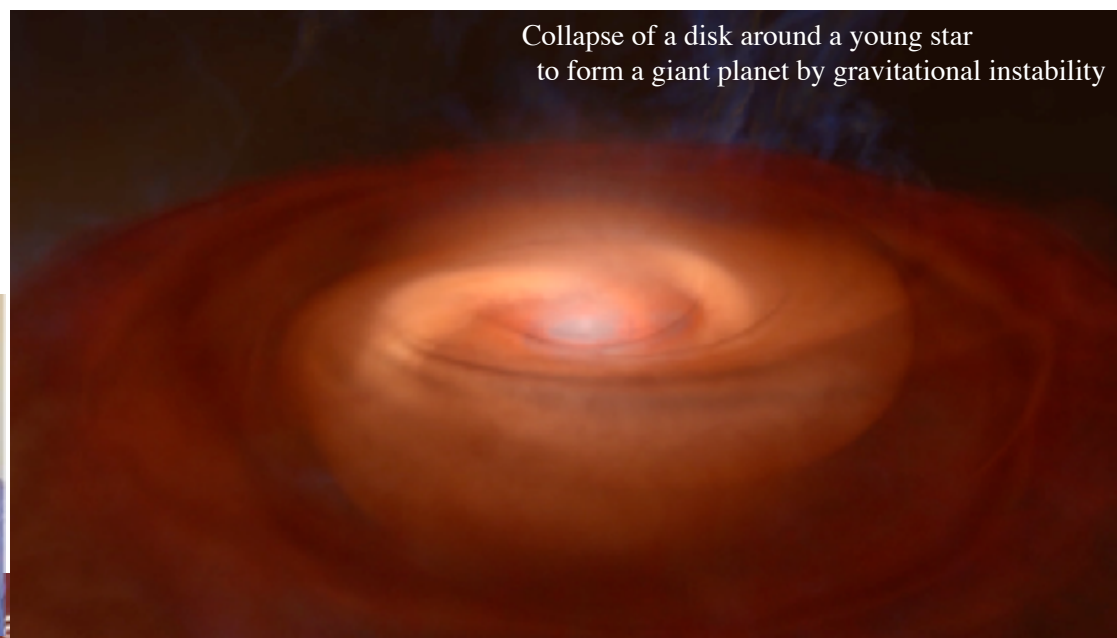
Konstatin Batygin



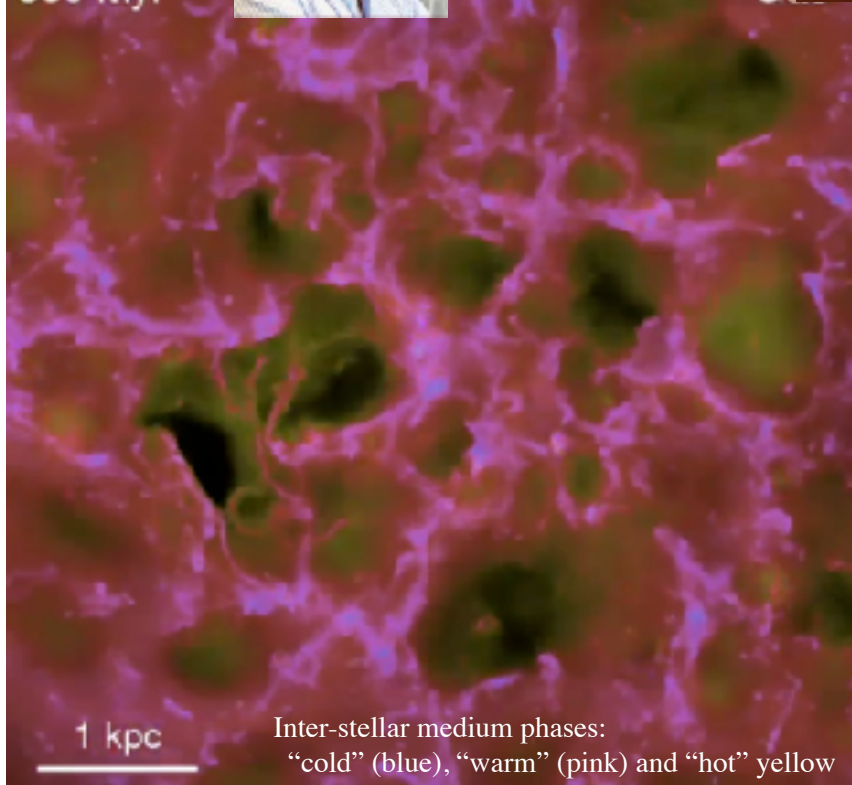
Phil Hopkins



Collapse of a disk around a young star
to form a giant planet by gravitational instability



580 Myr



Inter-stellar medium phases:
“cold” (blue), “warm” (pink) and “hot” yellow

- How do stars form? Why isn't everything a star?
- How do planets form? Why are there planets unlike anything in our solar system?
- How does this impact back on stars/galaxies?
- Chaotic dynamics, turbulence, radiation, magnetic fields, and self-gravitating fluids, all together at last!

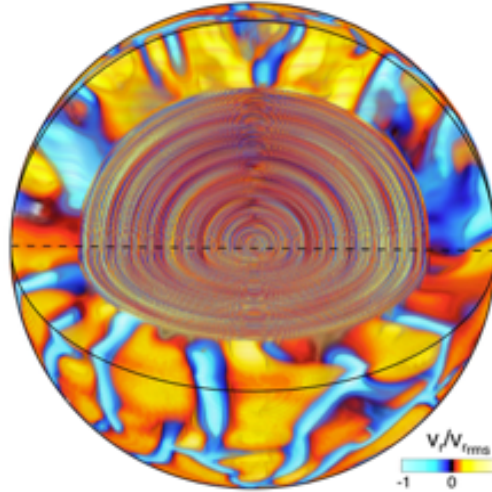
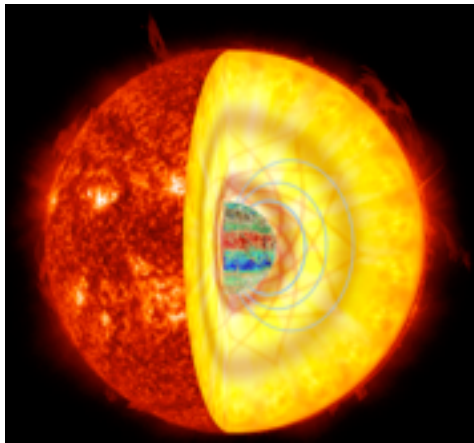
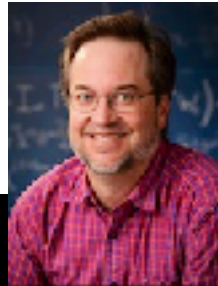
Explosions, Extreme Stars, & Stellar Evolution

- EXTREME PHYSICS & GRAVITATIONAL-WAVE COUNTERPARTS

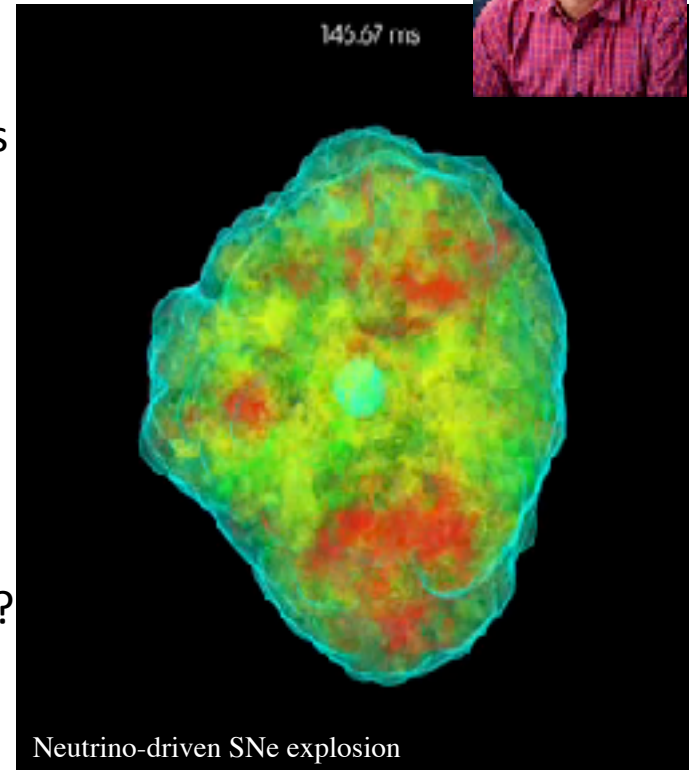
Saul Teukolsky



Mark Scheel



- Supernovae explosions: GR-neutrino-magneto-hydrodynamics, gravitational wave signals, nuclear physics in extreme systems
- Astro-seismology: Seeing inside stars and SNe; using Saturn's rings to probe earthquakes deep inside; new plasma physics
- White dwarf mergers: New stars? Supernovae?
- Neutron star mergers: Origins of gold and other elements? New GR tests! Seeing the counterparts in gravitational waves!



Neutrino-driven SNe explosion

High-Energy Astrophysics

Sterl Phinney

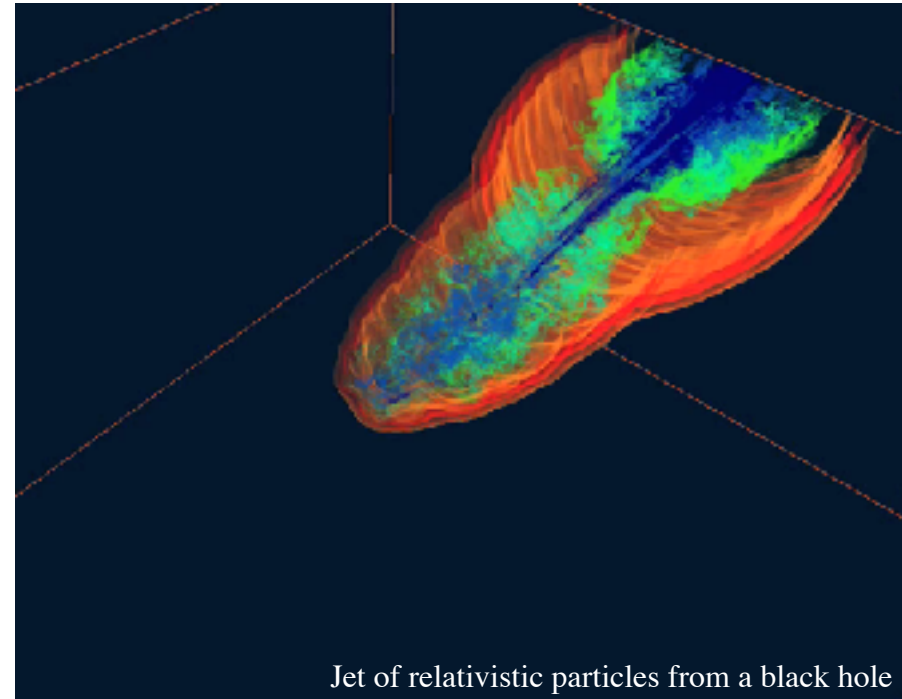


Jim Fuller



Cataclysmic variable accreting mass from a companion star

- White dwarfs, neutron stars, and black holes: Why do they light up? How do they form?
- Flares? Supernovae? Variables? Disruption? Connected to major observational searches (ZTF, LIGO, NuStar, and more)
- Mergers & electromagnetic signatures from compact objects (LIGO & LISA)
- Plasma physics in extreme environments



Jet of relativistic particles from a black hole

Theoretical Relativity & Gravitational Waves

Saul Teukolsky

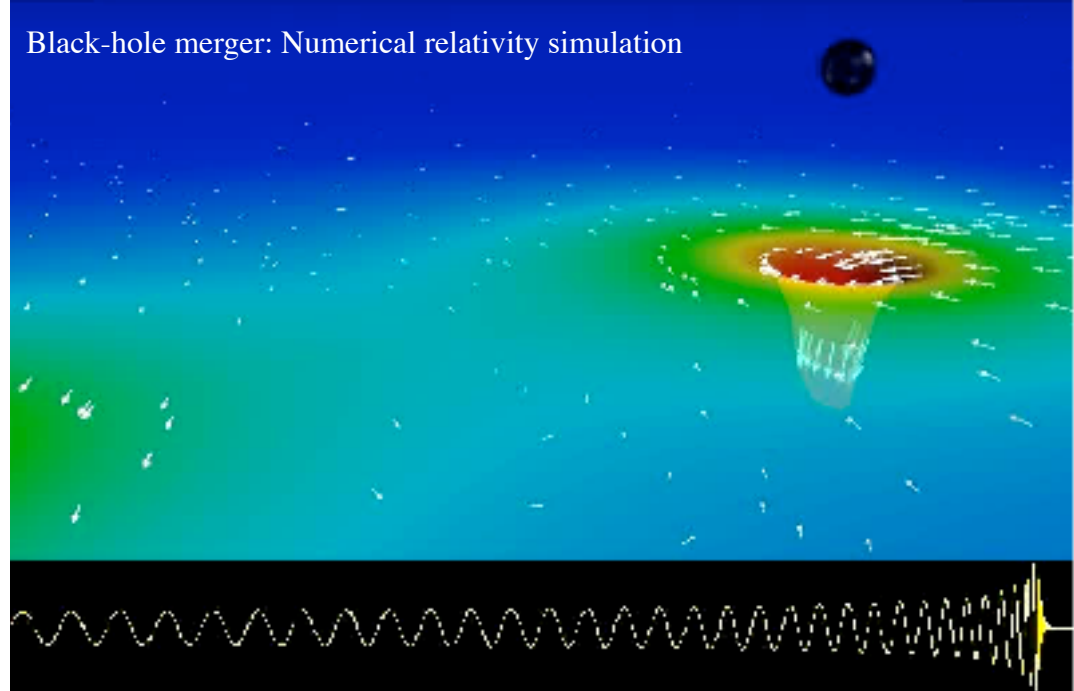


Mark Scheel

Yanbei Chen



Black-hole merger: Numerical relativity simulation

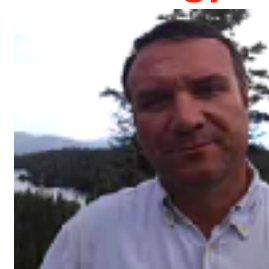


- Predict & understand LIGO events. New GR discoveries
- Analytic & numerical GR: understand fundamental predictions of relativity
- Test relativity & alternative gravity theories
- Design 3rd-generation gravitational wave detectors (LIGO 3, quantum non-demolition, macroscopic QM: “Quantum optics” for new GR tests)
- Astrophysics: BH spin, growth, kicks, gamma-ray bursts, neutron-star mergers, supernovae

Kip Thorne



Bela Szilagyi



Curt Cutler



Michele Vallisneri

